Weighted-Vest Exercise: Fall Risk, BMD and Hip Fracture

Christine M. Snow, PhD, FACSM

A program of resistance training plus impact is producing positive effects on parameters related to fall risk and hip fracture. Postmenopausal women are experiencing improvements in strength, balance, body composition and, in the long-term, BMD maintenance.

With more than 300,000 hip fractures sustained annually in the United States, and an anticipated doubling of this number by the year 2040,[1] it is not an exaggeration to say that the hip fracture problem is reaching epidemic proportions. The monetary cost associated with hip fractures—more than $9 billion annually[2]—is just part of the story; hip fracture is a major cause of morbidity, loss of independence, nursing home placement and general health deterioration. Furthermore, the psychological burden that accompanies hip fracture can be devastating with respect to loss of independence and quality of life. In a recently published study involving women over the age of 75 years, Salkeld and colleagues report that 80% of those surveyed said they would rather be dead than be admitted to a nursing home subsequent to a hip fracture.[3]

It is now well established that falls and decreases in bone mineral density (BMD) are primary risk factors for hip fracture.[4] Ninety percent of hip fractures and approximately 50% of vertebral fractures are the result of falls;[5-7] the risk of hip fracture is increased 6-fold with falls to the side, and 20-fold with falls directly on the greater trochanter.[8,9]

Because increasing BMD and reducing falls play such critical roles in fracture prevention, and because resistance exercise has been shown to increase BMD and improve factors associated with fall risk, a study to evaluate the effects of resistance training on hip fracture in healthy older women was conducted at the Bone Research Laboratory of Oregon State University. Five years after the study's completion, a second study was undertaken with some of the original participants, to assess the long-term effects of the exercise regimen. This article provides an overview of both studies and describes the weighted-vest resistance-training program that was utilized.

Initial Study: Weighted-Vest Exercise and Fall Risk

The first phase of the study, initiated in 1995,[10] was designed to evaluate the effects of a 9-month regimen of weight-bearing resistance exercise on dynamic balance, muscle strength and bone mass in healthy postmenopausal women. The premise of the study was that improving these factors would, in turn, reduce the risk of falls and hip fractures.

A total of 48 healthy, active postmenopausal women were recruited for the study; all were Caucasian, were at least 5 years past menopause (between 50 and 75 years of age, average 63), were nonsmokers and were taking no medications known to alter bone metabolism (with the exception of estrogen). At baseline women underwent dual-energy x-ray absorptiometry (DXA) to determine BMD of the right proximal femur, and whole-body DXA to quantify lean and fat mass. Indices of postural stability, muscular power of the lower extremities and peak force of the ankle plantar and dorsiflexors, hip abductors and knee extensors were also assessed. Ultimately, 22 women were assigned to the exercise group and 15 to the control group.

Weighted vests. Central to the exercise regimen was the use of weighted vests—rather than traditional weights or weight machines—to provide overload to the musculoskeletal system. The vest (Figure) fits comfortably around the body, leaving the arms free to move. Half-pound weights are slid into the vest's pockets, allowing weight to be well distributed around the torso, rather than concentrated in the front or back of the body. Use of the half-pound weights also allowed us to increase weight in small, controlled increments throughout the course of the exercise program.

The vests also enabled participants to perform the exercises in a standing position, providing optimal loading of the hips, which is so critical for bone development and maintenance. Standing also re-

Figure. Exercise vest and half-pound weights.

quires more postural challenge; we believed that adding resistance in standing exercises, and in some that mimic everyday activities, would provide more of a challenge for the postural mechanisms and would, therefore, reduce fall risk.

Resistance-training program. The women attended 60-minute classes three times a week, with at least 1 day of rest between classes. Each class began with 10 minutes of warm-up activities and ended with 10-15 minutes of cool-down activities. The exercise program focused on increasing lower-extremity strength and power. Emphasis was placed on activities that would challenge dynamic stability, since balance and gait are primary risk factors for falls,[11] and most falls occur during ambulation.[6] To this end, the exercises included chair raises, squats (standing and bending at the knees), toe raises, stepping (to mimic stair climbing) and forward lunges. Because falling to the side is such an important risk for hip fracture, the exercise program also included modified lunges and other activities that involved stepping to the side, to challenge and improve mediolateral stability and balance. In light of evidence of the effect of impact activities on hip BMD,[12,13] jumping in place (without the weighted vest) was added to the program. Participants jumped in place (in sets of five) while bending slightly at the knees and hips. It is interesting to note that the women were initially concerned about this exercise, but it soon became their favorite activity. (Jumping should not be initiated until participants have engaged in at least 3 months of lower-body resistance training; in our study use of the weighted vests built the knee and hip strength needed to support the jumping activity.)

The exercises were performed without the weighted vests for the first 2 weeks of the study. Exercises were performed in three sets of 10-15 repetitions and, after the first 2 weeks, intensity was increased gradually with the addition of weights to the vest. The women were weighed once each week, and initial vest resistance was set at 5% of body weight. Weight was gradually increased (approximately 1-2% every 2 weeks) up to 10% of body weight. In this way, resistance was progressively increased; the highest resistance achieved by the end of the program was 16-20% of body weight.

Results. The studies performed at baseline were repeated at the end of the study period. After 9 months these already active postmenopausal women experienced tremendous gains in strength, power and mediolateral balance (30-40% in the lower extremities), a 4% increase in muscle mass and an 8% decrease in body fat in the legs. All of these values were statistically different from those of the women in the control group, who demonstrated no significant changes in any of these parameters. The women in the exercise group reported noticeable changes in the musculature of their legs, noting that they hadn't seen such definition before, even when much younger. There were no significant changes in BMD, as compared to the controls, although there was a trend for increases of just under 1%.

In addition to the objective measures, we also assessed self-concept and self-esteem. The program and the results were so empowering that 40% of the women who participated in the study continued with the exercise program. It was, in fact, the women's enthusiasm and willingness to continue with the program that enabled us to conduct a second study, some 5 years later, to evaluate the long-term effects of the resistance-training regimen.

Follow-Up Study: Long-Term Weighted-Vest Exercise and Hip BMD

The weighted-vest resistance-training program became—and remains—a community program, with classes taught at the local community college in 10-week sessions. Nine of the women in the original study participated in these classes, exercising approximately 40 weeks per year during the 5 years since completion of the initial study; an additional nine women remained active but did not engage in weighted-vest or jumping activities. During those 5 years, compliance with the exercise regimen was extremely high (>83%); weighted vests averaged 11.3 pounds, and jumps per session averaged 51.7.[14]

After 5 years of participation, BMD at the femoral neck, trochanter and total hip was maintained in the exercise group, while every control experienced a true decrease in BMD at these sites (by 3.2-4.4%).[14] (Calcium and vitamin D intake were similar in the exercise and control groups, and did not represent confounding variables.) Interestingly, among those who maintained BMD with long-term resistance training was an 80-year-old woman who had been osteoporotic at the hip (by DXA) when she enrolled in the initial study.

Our long-term study is, to our knowledge, the first to assess the effects of more than 5 years of exercise on BMD in older women. Of note is the fact that we experienced no attrition; as stated above, compliance was extremely high. This latter finding is important in light of exercise regimens for osteoporosis prevention that are criticized for their inability to motivate the continuing participation needed

to achieve clinically relevant outcomes. As reported in our study findings, the program "promoted motivation in participants by creating an environment of individual encouragement and support, and by showing visible results."[14] This occurred among the participants as they exercised together and relied upon one another for support. We believe a similar result would be apparent in a small group of women exercising together in a home environment with the aid of educational video tapes.[14]

Among the study's limitations were the small sample size and the fact that women were not randomized into the exercise or control groups, but instead decided whether to exercise at the onset of the study. In addition, while not all of the women in the study were estrogen-deplete, five (two in the exercise group and three controls) had been taking estrogen replacement for more than 1 year prior to baseline testing; these women were considered stable with regard to skeletal status.

Conclusions

It appears that resistance exercise plus impact (through jumping) resulted in reduced hip bone loss after 5 years of participation in the program described above. We attribute our results to several factors: performance of the exercises in a standing position (providing overload), the high loading rate provided by the jumping, and the duration of the program. It is, of course, important that lower loading rates be used with older individuals, in the interest of safety. It is also important to note that a bone response from loading, such as that provided by the jumping activity, will probably take longer to achieve in an older skeleton than in a younger one.

To date, there appear to be very few contraindications to participation in resistance-training programs, such as the one described in this article. While significant orthopedic problems or osteoporotic fractures (e.g., hip or multiple vertebral fractures) might be considered contraindications, a number of the women in our study had been diagnosed with osteoporosis (by DXA) upon entry. After 5 years, two of these women no longer had osteoporosis and the other had maintained her hip BMD. Some study participants with osteoarthritis actually experienced pain relief because of joint stability enhanced by increased muscle strength. In addition, some of the women currently enrolled in the program have undergone knee and hip replacements. Women should, of course, be advised to check with their clinicians before beginning any exercise program. Instructor training for the weighted-vest resistance training program was begun 3 years ago, and steps are now being taken to pursue reimbursement for hospital-based programs.

Anecdotally, women have conveyed their enthusiasm for the results achieved with the program in many ways: Some women report that they are now able to recover from stumbles that previously would have resulted in falls, others note that they are using stairs more often, and still others report that they are able to "ski better" or "hike longer." The common thread throughout these reports is one of empowerment, both on an individual and a group basis; exercising and achieving results as a group can be highly motivating and can help provide the encouragement needed to commit to a long-term program.

There is little doubt that exercise can yield excellent results in terms of general health and fall prevention. There is evidence, albeit limited, for an additive effect of estrogen plus exercise on BMD at the spine and at Ward's triangle of the hip, and for an enhanced whole-body BMD effect.[15] Assuming that long-term compliance could be ensured, resistance training might ultimately serve as an alternative to hormone replacement therapy (HRT) for bone protection and fracture prevention in women who should not or choose not to use HRT; additional research is warranted in this area. ■

Christine M. Snow, PhD, FACSM, is Director, Bone Research Laboratory, and Professor, Department of Exercise and Sport Science, Oregon State University, Corvallis. More information about the weighted vests and instructional videos for the resistance-training program can be found at www.bonesandbalance.com.

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